

WHAT IS CLAIMED IS:

1. A radio frequency (RF) down-convertor with reduced local oscillator leakage, for demodulating an input signal $x(t)$, comprising:

a synthesizer for generating mixing signals ϕ_1 and ϕ_2 which vary irregularly over time, where $\phi_1 * \phi_2$ has significant power at the frequency of a local oscillator signal being emulated, and neither ϕ_1 nor ϕ_2 has significant power at the frequency of said local oscillator signal being emulated;

a first mixer coupled to said synthesizer for mixing said input signal $x(t)$ with said mixing signal ϕ_1 to generate an output signal $x(t) \phi_1$; and

a second mixer coupled to said synthesizer and to the output of said first mixer for mixing said signal $x(t) \phi_1$ with said mixing signal ϕ_2 to generate an output signal $x(t) \phi_1 \phi_2$.

2. The radio frequency (RF) down-convertor of claim 1 wherein said synthesizer further comprises:

a synthesizer for generating mixing signals ϕ_1 and ϕ_2 , where $\phi_1 * \phi_1 * \phi_2$ does not have a significant amount of power within the bandwidth of said input signal $x(t)$ at baseband.

3. The radio frequency (RF) down-convertor of claim 2, further comprising:
a DC offset correction circuit.

4. The radio frequency (RF) down-convertor of claim 3, wherein said DC offset correction circuit comprises:

a DC source having a DC output; and

a summer for adding said DC output to an output of one of said mixers.

5. The radio frequency (RF) down-convertor of claim 2, further comprising:
a closed loop error correction circuit.

6. The radio frequency (RF) down-convertor of claim 5, wherein said closed loop error correction circuit further comprises:

an error level measurement circuit and

a time-varying signal modification circuit for modifying a parameter of one of said mixing signals ϕ_1 and ϕ_2 to minimize said error level.

7. The radio frequency (RF) down-converter of claim 6, wherein said error level measurement circuit comprises a power measurement.
8. The radio frequency (RF) down-converter of claim 6, wherein said error level measurement circuit comprises a voltage measurement.

9. The radio frequency (RF) down-converter of claim 6, wherein said error level measurement circuit comprises a current measurement.
10. The radio frequency (RF) down-converter of claim 6, wherein said modified parameter is the phase delay of one of said mixing signals ϕ_1 and ϕ_2 .
- a^2 11. The radio frequency (RF) down-converter of claim 6, wherein said modified parameter is the fall or rise time of one of said mixing signals ϕ_1 and ϕ_2 .
12. The radio frequency (RF) down-converter of claim 6, wherein said modified parameter includes both the phase delay and the fall or rise time of one of said mixing signals ϕ_1 and ϕ_2 .
13. The radio frequency (RF) down-converter of claim 2 wherein said synthesizer further comprises:
a synthesizer for generating mixing signals ϕ_1 and ϕ_2 , where said mixing signals ϕ_1 and ϕ_2 can change with time in order to reduce errors.

14. The radio frequency (RF) down-converter of claim 1, further comprising:
a filter for removing unwanted signal components from said $x(t)$ ϕ_1 signal.

15. The radio frequency (RF) down-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are random.
- a^3 16. The radio frequency (RF) down-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are pseudo-random.
17. The radio frequency (RF) down-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are irregular.

18. The radio frequency (RF) down-convertor of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are digital waveforms.

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cont 19. The radio frequency (RF) down-convertor of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are square waveforms.
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20. The radio frequency (RF) down-convertor of claim 1, further comprising:
a local oscillator coupled to said synthesizer for providing a signal having a frequency that is an integral multiple of the desired mixing frequency.
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- a4 21. A method of demodulating a radio frequency (RF) signal $x(t)$ with reduced local oscillator leakage comprising the steps of:
generating mixing signals ϕ_1 and ϕ_2 which vary irregularly over time, where ϕ_1 and ϕ_2 has significant power at the frequency of a local oscillator signal being emulated, and neither ϕ_1 nor ϕ_2 has significant power at the frequency of said local oscillator signal being emulated;
mixing said input signal $x(t)$ with said mixing signal ϕ_1 to generate an output signal $x(t) \phi_1$;
and
mixing said signal $x(t) \phi_1$ with said mixing signal ϕ_2 to generate an output signal $x(t) \phi_1 \phi_2$.
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22. An integrated circuit comprising the radio frequency (RF) down-converter of claim 1.
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25. The radio frequency (RF) down-converter of claim 1, where said synthesizer uses different patterns to generate signals ϕ_1 and ϕ_2 .
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- a5 26. The radio frequency (RF) down-converter of claim 1, wherein said synthesizer uses a single time base to generate both mixing signals ϕ_1 and ϕ_2 .
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WHAT IS CLAIMED IS:

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1. A radio frequency (RF) down-converter with reduced local oscillator leakage, for demodulating an input signal $x(t)$, comprising:
a synthesizer for generating mixing signals ϕ_1 and ϕ_2 which vary irregularly over time, where $\phi_1 + \phi_2$ has significant power at the frequency of a local oscillator signal being emulated, and neither ϕ_1 nor ϕ_2 has significant power at the frequency of said local oscillator signal being emulated;
a first mixer coupled to said synthesizer for mixing said input signal $x(t)$ with said mixing signal ϕ_1 to generate an output signal $x(t) \phi_1$; and
a second mixer coupled to said synthesizer and to the output of said first mixer for mixing said signal $x(t) \phi_1$ with said mixing signal ϕ_2 to generate an output signal $x(t) \phi_1 \phi_2$.
 2. The radio frequency (RF) down-converter of claim 1 wherein said synthesizer further comprises:
a synthesizer for generating mixing signals ϕ_1 and ϕ_2 , where $\phi_1 + \phi_1 + \phi_2$ does not have a significant amount of power within the bandwidth of said input signal $x(t)$ at baseband.
 3. The radio frequency (RF) down-converter of claim 2, further comprising:
a DC offset correction circuit.
 4. The radio frequency (RF) down-converter of claim 3, wherein said DC offset correction circuit comprises:
a DC source having a DC output; and
a summer for adding said DC output to an output of one of said mixers.
 5. The radio frequency (RF) down-converter of claim 2, further comprising:
a closed loop error correction circuit.
 6. The radio frequency (RF) down-converter of claim 5, wherein said closed loop error correction circuit further comprises:
an error level measurement circuit and
a time-varying signal modification circuit for modifying a parameter of one of said mixing signals ϕ_1 and ϕ_2 to minimize said error level.

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7. The radio frequency (RF) down-converter of claim 6, wherein said error level measurement circuit comprises a power measurement.
8. The radio frequency (RF) down-converter of claim 6, wherein said error level measurement circuit comprises a voltage measurement.
9. The radio frequency (RF) down-converter of claim 6, wherein said error level measurement circuit comprises a current measurement.
10. The radio frequency (RF) down-converter of claim 6, wherein said modified parameter is the phase delay of one of said mixing signals ϕ_1 and ϕ_2 .
11. The radio frequency (RF) down-converter of claim 6, wherein said modified parameter is the fall or rise time of one of said mixing signals ϕ_1 and ϕ_2 .
12. The radio frequency (RF) down-converter of claim 6, wherein said modified parameter includes both the phase delay and the fall or rise time of one of said mixing signals ϕ_1 and ϕ_2 .
13. The radio frequency (RF) down-converter of claim 2 wherein said synthesizer further comprises:
a synthesizer for generating mixing signals ϕ_1 and ϕ_2 , where said mixing signals ϕ_1 and ϕ_2 can change with time in order to reduce errors.
14. The radio frequency (RF) down-converter of claim 1, further comprising:
a filter for removing unwanted signal components from said $x(t)$ ϕ_1 signal.
15. The radio frequency (RF) down-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are random.
16. The radio frequency (RF) down-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are pseudo-random.
17. The radio frequency (RF) down-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are irregular.

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18. The radio frequency (RF) down-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are digital waveforms.
19. The radio frequency (RF) down-converter of claim 1, wherein said mixing signals ϕ_1 and ϕ_2 are square waveforms.
20. The radio frequency (RF) down-converter of claim 1, further comprising:
a local oscillator coupled to said synthesizer for providing a signal having a frequency that is an integral multiple of the desired mixing frequency.
21. The radio frequency (RF) down-converter of claim 1, wherein said synthesizer uses a single time base to generate both mixing signals ϕ_1 and ϕ_2 .
22. The radio frequency (RF) down-converter of claim 1, where said synthesizer uses different patterns to generate signals ϕ_1 and ϕ_2 .
23. A method of demodulating a radio frequency (RF) signal $x(t)$ with reduced local oscillator leakage comprising the steps of:
generating mixing signals ϕ_1 and ϕ_2 which vary irregularly over time, where $\phi_1 \neq \phi_2$ has significant power at the frequency of a local oscillator signal being emulated, and neither ϕ_1 nor ϕ_2 has significant power at the frequency of said local oscillator signal being emulated;
mixing said input signal $x(t)$ with said mixing signal ϕ_1 to generate an output signal $x(t) \phi_1$; and
mixing said signal $x(t) \phi_1$ with said mixing signal ϕ_2 to generate an output signal $x(t) \phi_1 \phi_2$.
24. An integrated circuit comprising the radio frequency (RF) down-converter of any one of claims 1 - 22.
25. A computer readable memory medium, storing computer software code in a hardware development language for fabrication of an integrated circuit comprising the radio frequency (RF) down-converter of any one of claims 1 - 22.
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A computer data signal embodied in a carrier wave, said computer data signal comprising computer software code in a hardware development language for fabrication of an integrated circuit comprising the radio frequency (RF) down-converter of any one of claims 1 - 22.